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Ground or Swimming Pool Exercises for Women with Knee Osteoarthritis? A Double-blind Randomized Clinical Trial

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Authors' contributions

This work was carried out in collaboration between all authors. Authors MBD and RBD designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors RMC, PHGP and AFB managed the analyses of the study. Author RMC managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Objectives: To compare the effectiveness of closed kinetic chain (CKC) exercises performed on the ground and in the swimming pool in women with knee osteoarthritis (KOA).
Study Design: Double-Blind Randomized Clinical Trial.
Place and Duration of the Study: Clinical School of Physiotherapy of Ulbra Torres, from March 2015 to June 2017.
Methodology: Thirty-four women with grade 1 and 2 knee knee OA were allocated into two groups. One group received treatment with CKC exercises on the ground (n = 17) and the other group had the same exercises performed in the swimming pool (n = 17) for a period of two months, three times a week, totaling 24 sessions. Subjects were initially assessed prior to randomization, after 12 sessions, after 24 sessions and 3 months after the end of the protocol. The following variables were evaluated: pain, knee joint mobility, hamstring flexibility, hamstring and quadriceps muscle strength and functionality.
Results: There was an improvement in hamstring flexibility with 12 sessions in the pool group and

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at the end of the protocol in both groups (P<.05). The range of motion of knee flexion increased in both study groups after the intervention (P<.05). The pool group demonstrated a reduction of this gain in the follow-up. Pain decreased similarly in both groups (P<.05). The pool group showed an initial quadriceps strength and left hamstring strength lower than the ground group. However, at the end of the protocol, both groups improved muscle strength in both knees (P<.05). The Lequesne and WOMAC scores reduced significantly with 12 sessions in both groups (P<.05), remaining likewise in the follow-up.

Conclusion: CKC exercises performed both on the ground and in the swimming pool promoted a decrease in pain and joint stiffness, also improving the mobility, muscle strength and functionality of patients with knee OA.

Keywords: Knee osteoarthritis; closed kinetic chain exercises; aquatic physiotherapy.

ABBREVIATIONS

OA = *Osteoarthritis*
VAS = *Visual analog scale of pain*
CKC = *Closed kinetic chain*
Min = *Minutes*
Sec = *Seconds*
WOMAC = *Western Ontario and McMaster Universities Osteoarthritis Index*

1. INTRODUCTION

Osteoarthritis (OA) is the most common form of arthritis, being a prevalent joint disease and the main cause of pain and physical disability in the elderly population [1]. As life expectancy increases, there is likely to be a significant increase in the incidence of this pathology in the next twenty years [2]. OA is characterized by wear of the cartilage that overlaps the articular surfaces, with formation of fibrillation and fissure areas, cysts, subchondral bone sclerosis, and even formation of osteophytes at the joint edges [3,4].

Knee OA, also known as gonarthrosis, is a slow-growing and generalized pathology, having as main complaints pain, stiffness, instability and loss of function [5]. Knee OA limits weight transfer activities such as walking, climbing and descending ladders, and rising from a chair [5].

Muscle imbalance between knee flexors and extensors may not only be the consequence of knee OA, but also the cause, associated with known degenerative processes leading to functional disability and future deformities [3]. In addition to this muscular imbalance, aging, obesity, trauma, joint surgery, hormonal imbalance, heredity, nutrition and bone density are other factors that also predispose to knee OA [4].

Among the different types of exercises used in the rehabilitation of knee OA, closed kinetic chain (CKC) exercises are shown to be more functional, in addition to providing a better restoration of muscle strength without damaging the patellofemoral joint [6]. Low-impact aerobic exercises are of great importance in the therapeutic approach for symptomatic knee OA patients. In the same way, flexibility exercises, ground exercises, quadriceps strengthening and resistance exercises are some of the activities used in the treatment of knee OA [7]. These activities reduce knee pain, physical disability and are equally effective in improving functional status, gait, pain and aerobic capacity in people with knee OA [8,9].

Aquatic physiotherapy offers several advantages for people with OA [10]. Buoyancy reduces the load on all pain-affected joints and allows for functional CKC exercises that, at certain stages of the disease, can be very difficult and more painful when performed on the ground. Water turbulence can be used as a method of increasing resistance and in this medium the percentage of body weight supported between the lower limbs may be decreased or increased in proportion to the immersion depth. In addition, the heat and pressure of water can decrease edema, joint pain and improve locomotion [11].

Due to the increase in the number of people with this pathology and the existence of few studies comparing ground and water exercises in this population and the results are conflicting in the use of this technique (CKC) in the ground and swimming pool, this study aimed to compare the effectiveness of CKC exercises on the ground and in the swimming pool in women with knee OA.

2. MATERIALS AND METHODS

The present study is characterized as a double-blind randomized clinical trial. The study was approved by the Human Research Ethics

Committee of the Lutheran University of Brazil under number 473.141. The research took place from March 2015 to June 2017 at the Clinical School of Physiotherapy of the Lutheran University of Brazil (ULBRA) in the city of Torres/RS, Brazil. Altogether, 45 patients diagnosed with knee OA were selected. Of these, 34 patients met the eligibility criteria and completed the study.

Included in the study were women with grade 1 and 2 knee OA in the Kellgren-Lawrence scale, with clinical and radiological diagnosis performed by an independent traumatologist, age between 40 and 80 years, and who signed the Free and Informed Consent Term. The radiological criteria were established by Kellgren and Lawrence represents an ordinal scale of five levels. Grade 0 thus indicated a definite absence of x-ray changes of osteoarthritis, Grade one, known as the pre-arthrosis stage, and demonstrates a dubious narrowing of joint space and possible osteophytes. Grade 2 that osteoarthrosis was in our opinion definitely present though of minimal severity. Grade three is characterized by sharp osteophytes and moderate articular space narrowing, some subchondral ossicle sclerosis, and possible deformity. Finally, grade four shows large osteophytes, significant articular space narrowing, severe sclerosis, and defined deformity.

Exclusion criteria were grade 3 and 4 knee OA in the Kellgren-Lawrence radiological classification, non-ambulatory patients, neurological diseases leading to cognitive deficits, psychiatric disorders, symptomatic heart disease, patients with clinical manifestations that do not allow exercise, presence of cutaneous infection or other skin disease, urinary incontinence, history of previous knee injury (meniscus, ligament, sprains), patients with previous history of knee joint infiltration in the last three months, rheumatologic diseases (rheumatoid arthritis, lupus erythematosus or gout), history of knee trauma or surgery in the last six months, patients participating in another knee rehabilitation program, patients with water phobia, three consecutive unexcused absences.

We initially selected 45 subjects. Of these, 11 patients were excluded from the study because they did not meet the eligibility criteria. Therefore, the initial sample consisted of 34 patients. In the follow-up evaluation, 18 subjects were not found for the evaluation due to change of address/telephone (Fig. 1).

After signing the Free and Informed Consent Term, the patients were randomized through envelopes containing the name of the group to which the patient would belong, in CKC Ground group (n = 17) and CKC Pool group (n = 17).

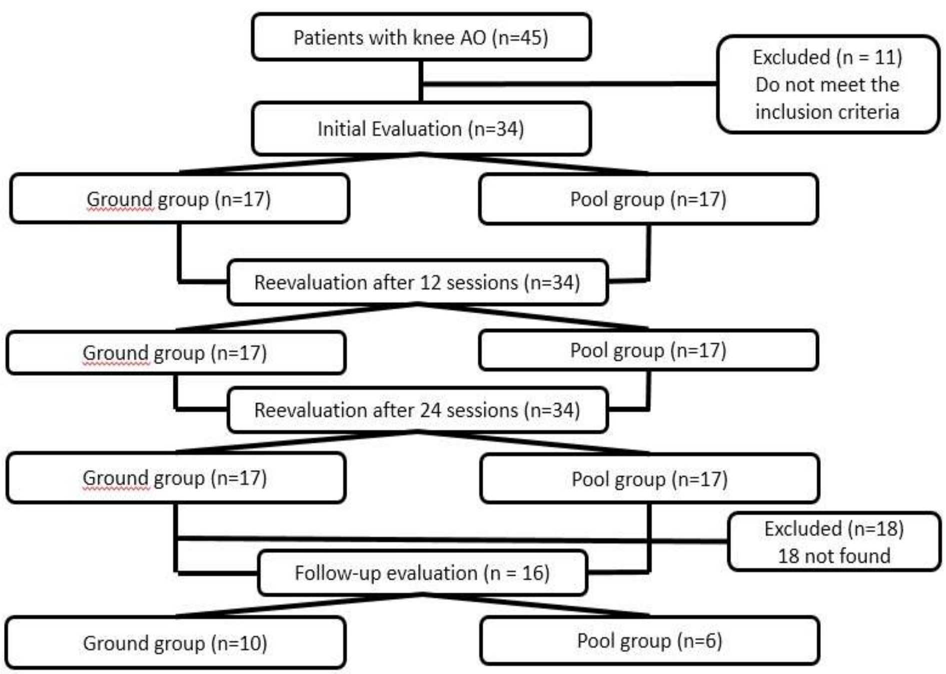

Fig. 1. Study flowchart

2.1 Evaluation Protocol

A blind evaluator, that is, performed the evaluations without knowledge of which group the patient belonged to. The evaluations occurred at three different times within the study period: the first took place prior to randomization and at the beginning of the therapeutic program, the second after 12 treatment sessions, and the third after completion of treatment, i.e., after the 24th session; the follow-up evaluation took place 90 days after the end of treatment (Fig. 1).

The pain level was measured using the Visual Analogue Scale (VAS).

The range of motion (ROM) of knee flexion and extension was measured passively and actively using a goniometer (brand Carci®).

The assessment of posterior muscle chain flexibility was performed through the Wells Bank. The patient was seated with the legs outstretched and the feet resting on the device.

The maximal voluntary isometric contraction (MVIC) of the hamstrings and quadriceps was measured using a Chataanooga® manual push-pull dynamometer [10].

The quality of life and level of functionality were assessed using the Lequesne Scale and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) questionnaire for knee osteoarthritis [12].

2.2 Intervention Protocol

The proposed exercise protocol was performed three times a week for eight weeks. The exercises were performed in bipodal support, progressing to unipodal support according to the progression of the patient in the protocol. For both groups, a stationary bicycle warm-up was performed for 5 minutes (Table 1).

2.3 Statistical Analysis

The SPSS (Statistical Package for the Social Sciences) software version 17.0 was used as statistical package. Data were expressed as mean and standard deviation and analyzed statistically by one-way analysis of variance (ANOVA) for repeated measures, followed by the Bonferroni post hoc test for comparison of means between groups. For analysis between the groups, the unpaired Student's t-Test was used. Non-parametric data were analyzed using the Friedman test and the Mann-Whitney test. The significance level established for the statistical test was $p<0.05$.

Table 1. Exercise protocol for both study groups.

Group	Exercises	No. Rep./Time
CKC Ground	Warm-up	5 min.
	Mini squatting 0 - 30^0 degrees	3 x 10 rep
	Front step up and down	3 x 10 rep
	Lateral step up and down	3 x 10 rep
	Leg press	3 x10 rep
	Proprioceptive exercise on the rocker	3 x 10 sec.
	Proprioceptive board	3 x 10 sec.
	Frontal walking training	5 min.
	Lateral walking training	5 min.
	. Backwards walking training	5 min.
CKC Pool	1. Warm-up	5 min
	2. Mini squatting 0 - 30^0 degrees	3 x 10 rep
	3. Front step up and down	3 x 10 rep
	4. Lateral step up and down	3 x 10 rep
	5. Leg press	3 x 10 rep
	6. Float walking	1 min.
	7. Proprioceptive board	3 x 10 sec
	8. Frontal walking training	5 min.
	9. Lateral walking training	5 min.
	10.Backwards walking training	5 min.

Rep=repetition; min=minutes; sec=seconds.

3. RESULTS

We initially selected 45 patients with knee OA. Of these, 34 patients signed the Free and Informed Consent Term and met the inclusion criteria for participation in the study. The mean age was 59.29 ± 7.81 years, height of 158.00 ± 7.26 cm, weight of 76.94 ± 13.27 kg, and BMI of 30.94 ± 5.92 kg/m^2. Thirty-three (97.1%) subjects were white. Four (11.8%) subjects were classified with grade 1 OA and thirty (88.2%) with grade 2 OA in the Kellgren-Lawrence classification. Eleven (32.4%) subjects had bilateral injury, thirteen (38.2%) had right knee injury and ten (29.4%) had left knee injury. The mean time of knee pain was 61.56 ± 52.68 months. Thirty-one (91.2%) subjects were non-smokers. Eight (23.5%) used some type of viscosupplementation for 75.63 ± 30.29 months. The groups were homogeneous regarding gender, age, weight, stature, BMI, skin color, affected knee, time of pain, classification of the lesion, smoking habit and use of viscosupplementation (Table 2).

Prior to the intervention protocol, hamstring muscle flexibility was significantly lower in the CKC Pool group (*P*=.00). In the partial evaluation, only the CKC Pool group demonstrated a significant increase in flexibility (*P*=.04), which was even lower than the flexibility of subjects in the CKC Ground group (*P*=.08). At the end of the protocol, both groups significantly increased hamstring flexibility. In the CKC Pool group, this value increased from 16.44 ± 7.80, in the initial evaluation, to 24.81 ± 8.80 cm after the protocol (*P*=.000). On the other hand, patients in the CKC Ground group had this value increased from 24.41 ± 7.54 cm to 27.20 ± 7.86 cm (*P*=.004). There was no loss of flexibility in both groups at the 90-day evaluation (Table 3).

There was a significant improvement of the active ROM of right knee flexion in both groups after the intervention protocol (*P*<.05). Nonetheless, in the follow-up assessment, there was a loss of this ROM in the CKC Pool group in relation to the initial evaluation. Regarding the

Table 2. Characterization of the study subjects (n = 34)

Variable	**Total**	**Group**		***P* value**
		Ground group (n=17)	**Pool group (n=17)**	
Age, years (mean ± sd)	59.29 ± 7.81	58.94 ± 8.63	78.14 ± 16.83	0.71
Weight, kg (mean ± sd)	76.94 ± 13.27	74.17 ± 12.07	79.72 ± 14.17	0.54
Height, m (mean ± sd)	1.58 ± 0.73	1.55 ± 0.63	1.61 ± 0.73	0.34
BMI, (mean ± sd)	30.94 ± 5.92	30.29 ± 4.42	31.60 ± 7.20	0.42
Skin color, n (%)				0.31
White	33 (97.1)	17 (100.0)	16 (94,1)	
Black	1 (2.9)	0 (0.0)	1 (5,9)	
Occupation, n (%)				0,31
Retired	12 (35.3)	6 (35.3)	6 (35.3)	
Housewife	11 (32.4)	6 (35.3)	5 (29.4)	
Others	11 (32.3)	5 (29.4)	6 (35.3)	
Time of pain, months (mean ± sd)	61.56 ± 52.68	61.00 ± 47.58	62.12 ± 58.12	0.42
Kellgren-Lawrence classification, n (%)				0.29
Grade 1	4 (11.8)	3 (17.6)	1 (5.9)	
Grade 2	30 (88.2)	14 (82.4)	16 (94.1)	
Affected Knee				0.47
Right	13 (38.2)	8 (47.1)	5 (29.4)	
Left	10 (29.4)	5 (29.4)	5 (29.4)	
Bilateral	11 (32.4)	4 (23.5)	7 (41.2)	
Smoking, n (%)				0.55
Yes	3 (8.8)	1 (5.9)	2 (11.8)	
No	31 (91.2)	16 (94.1)	15 (88.2)	
Use of viscosupplementation, n (%)				1.00
Yes	8 (23.5)	4 (23.5)	4 (23.5)	
No	26 (76.5)	13 (76.5)	13 (76.5)	
Time of use of viscosupplementation, months (mean ± sd)	75.63 ± 30.29	68.25 ± 36.77	83.00 ± 20.62	0.51

BMI: body mass index; sd: standard deviation; kg: kilograms; cm: centimeters.

Table 3. Values obtained in hamstring flexibility and joint mobility in the study groups (n = 34)

Variable	Group		*P* value
	Ground group (n=17)	**Pool group (n=17)**	
Flexibility, cm			
Initial	24.41 ± 7.54	16.44 ± 7.80	0.00
Partial	25.53 ± 6.96	21.00 ± 7.60#	0.08
Final	27.76 ± 7.73#	24.81 ± 8.80#$	0.31
Follow-up	27.20 ± 7.86	24.33 ± 6.31	0.46
Active ROM right knee flexion, degrees			
Initial	105.59 ± 17.22	114.35 ± 20.01	0.18
Partial	108.65 ± 16.63	114.87 ± 18.71	0.32
Final	115.35 ± 16.27#$	121.06 ± 11.96#$	0.26
Follow-up	108.50 ± 19.01&	107.33 ± 34.89&	0.93
Active ROM left knee flexion, degrees			
Initial	110.13 ± 18.62	109.37 ± 17.63	0.91
Partial	110. 53 ± 16.05	111.60 ± 18.08	0.87
Final	113.67 ± 14.22	117.33 ± 14.12#$	0.48
Follow-up	110.00 ± 19.37	104.17 ± 33.53&$	0.66
Active ROM right knee extension, degrees			
Initial	- 2.94 ± 5.06	- 2.06 ± 5.87	0.66
Partial	- 1.76 ± 3.93	- .62 ± 2.50	0.33
Final	- 1.76 ± 4.31	- .67 ± 2.49	0.38
Follow-up	- 3.00 ± 5.37	- 1.67 ± 4.08	0.61
Active ROM left knee extension, degrees			
Initial	- 2.33 ± 4.95	- 2.76 ± 5.92	0.83
Partial	- 1.33 ± 3.52	- .67 ± 2.58	0.56
Final	- 1.00 ± 2.80	- .67 ± 2.58	0.73
Follow-up	- 1.50 ± 3.37	- 1.67 ± 4.08	0.93
Passive ROM right knee flexion, degrees			
Initial	119.41 ± 15.19	125.76 ± 15.82	0.24
Partial	120.35 ± 14.00	126.12 ± 15.11	0.26
Final	128.53 ± 15.08#$	130.31 ± 13.60#$	0.72
Follow-up	120.50 ± 20.61&	126.00 ± 22.76&	0.63
Passive ROM left knee flexion, degrees			
Initial	121.00 ± 14.42	120.31 ± 13.72	0.89
Partial	121.33 ± 14.45	125.33 ± 13.68#	0.44
Final	127.00 ± 16.23$	128.60 ± 13.75#	0.77
Follow-up	125.50 ± 17.86	117.50 ± 30.62&#	0.52
Passive ROM right knee extension, degrees			
Initial	- 1.18 ± 3.32	- 2.41 ± 8.52	0.58
Partial	- .06 ± 0.24	0.0 ± 0.0	0.34
Final	- .29 ± 1.21	- .31 ± 1.25	0.97
Follow-up	- 1.00 ± 3.16	- 1.67 ± 4.08	0.72
Passive ROM left knee extension, degrees			
Initial	- 0.67 ± 2.58	- 1.13 ± 3.77	0.70
Partial	0.0 ± 0.0	0.0 ± 0.0	1.00
Final	0.0 ± 0.0	0.0 ± 0.0	1.00
Follow-up	0.0 ± 0.0	- 1.67 ± 4.08	0.21

cm: centimeters; ROM: range of motion; # P<.05 compared to the initial evaluation; $ P<.05 compared to the partial evaluation; & P<.05 compared to the final evaluation

left knee, only the Pool group presented a significant improvement of the active mobility in the final evaluation; in the follow-up assessment, there was a loss of the mobility gained during the intervention protocol (Table 3).

The passive ROM of bilateral knee flexion demonstrated a significant increase in both groups at the end of the intervention protocol (P<.05). In the follow-up, the CKC Pool group decreased the ROM in relation to the final evaluation, in both knees ($P<.05$), while the CKC Ground group demonstrated a reduction in the passive flexion ROM only in the right knee ($P<.05$) (Table 3).

There were no significant differences in the ROM between the study groups (Table 3).

The pain level of the subjects of both groups decreased significantly throughout the treatment. The mean pain level for the CKC Ground group was 5.41 ± 2.53 in the first evaluation, while in the CKC Pool group this value was 5.68 ± 2.59. After 12 sessions, we observed a reduction to 4.00 ± 2.37 ($P=.006$) in the CKC Ground group and to 3.48 ± 2.48 in the CKC Pool group ($P=.03$). After the 24 sessions, the CKC Ground group presented a mean pain of 3.53 ± 1.91 and the CKC Pool group presented 3.21 ± 2.30, demonstrating a maintenance of the levels achieved with 12 sessions. In the follow-up evaluation, pain levels were, respectively, 4.50 ± 2.12 and 4.17 ± 2.48. There were no differences between groups in any of the evaluations (Fig. 2).

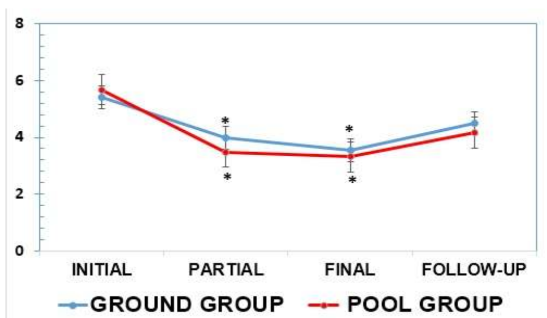

Fig. 2. Assessment of pain level (VAS) in the study groups

** P<.05 compared to the final evaluation in the same group; One-way ANOVA for repeated measures*

Subjects in the CKC Pool group showed a significantly lower muscle strength in left quadriceps ($P=.00$) and left hamstrings ($P=.00$) compared to subjects in the CKC Ground group prior to the intervention protocol. At the end of the protocol and in the follow-up evaluation, this difference was not observed (Fig. 3).

The right quadriceps muscle strength increased significantly in both groups at the end of the 24 sessions. The CKC Ground group presented, in the initial evaluation, 20.06 ± 10.13 kg. At the end of the protocol, the quadriceps strength increased to 23.00 ± 7.64 kg ($P=.05$). In the CKC Pool group, the initial strength was 19.88 ± 15.47 kg, increasing to 22.43 ± 10.63 kg after the intervention ($P=.05$) (Fig. 3).

Both groups increased the right hamstring strength at the end of the 24 sessions. In the CKC Ground group, it increased from 18.73 ± 6.72 kg to 22.53 ± 7.71 kg ($P=.00$). In the CKC Pool group, it increased from 16.82 ± 15.72 to 22.06 ± 11.49 ($P=.02$) (Fig. 3).

In the MVIC of the left quadriceps, the CKC Ground group did not show significant changes from the initial assessment to the follow-up evaluation. The CKC Pool group demonstrated a significant increase in strength after 12 sessions, increasing up to the end of the 24 sessions. In the CKC Pool group, the initial value was 10.32 ± 5.45 kg, rising to 14.09 ± 7.53 kg after 12 sessions ($P=.02$) and to 15.50 ± 7.89 kg at the end of the protocol ($P=.03$) (Fig. 3).

The left hamstring muscle strength of subjects from the CKC Ground group increased significantly at the end of the intervention protocol, whereas in the CKC Pool group there was an increasing and significant improvement until the follow-up evaluation. Initially, the left hamstring strength of the CKC Ground group was 15.07 ± 6.00 kg, increasing to 17.40 ± 5.54 kg at the end of the protocol ($P=.02$). On the other hand, the CKC Pool group initially demonstrated a muscle strength of 9.68 ± 7.85 kg. After 12 sessions, the muscle strength increased to 14.03 ± 8.62 kg ($P=.00$). After the protocol, there was an increase to 14.80 ± 8.55 kg ($P=.00$); in the follow-up, the value increased to 16.33 ± 3.72 kg ($P=.00$) (Fig. 3).

Both intervention groups demonstrated a reduction in the values of the Lequesne's Algofunctional Questionnaire, both at the end of the first twelve sessions and at the end of the protocol. The initial score of the CKC Pool group was significantly higher than that of the CKC ground group (Fig. 4).

The CKC Ground group presented an initial score of 9.97 ± 3.91 points, decreasing to 7.88 ± 3.99 points after 12 sessions ($P=.05$) and to 6.12 ± 4.10 points after the protocol. In the follow-up evaluation, there was no significant change in the score of this group ($P=.00$) (Fig. 4).

In the CKC Pool group, this value decreased from 13.21 ± 4.33 points to 9.41 ± 4.46 points after 12 sessions ($P=.03$) and to 7.92 ± 4.18 points after 24 sessions ($P=.00$). In the follow-up, the score decreased to 3.33 ± 1.63 points ($P=.00$) (Fig. 4).

The total WOMAC scores improved significantly in both study groups. The CKC Ground group showed improvement only after 24 sessions, while subjects in the CKC Pool group showed improvements already with 12 treatment sessions. No differences were found between the two groups (Table 4).

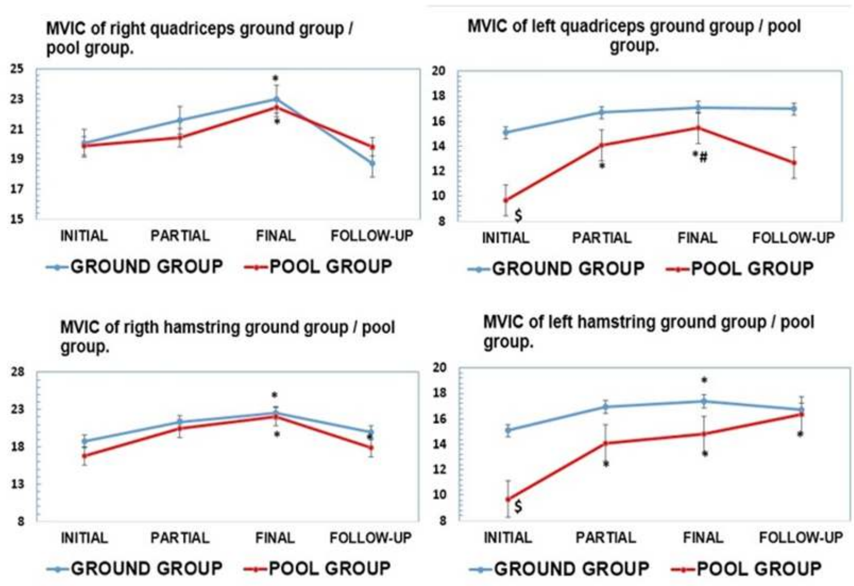

Fig. 3. Muscle strength analysis (MVIC) of the quadriceps and hamstrings in the study groups.
$ P<.05 compared to the same evaluation in the Ground group. Student's t-Test.
** P<.05 compared to the initial evaluation in the same group;*
 # P<.05 compared to the partial evaluation in the same group;
One-way ANOVA for repeated measures.

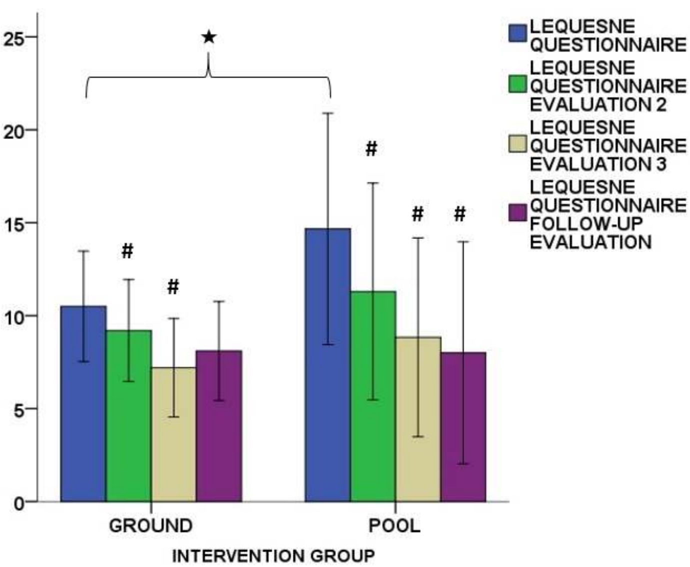

Fig. 4. Score of the Lequesne Questionnaire in the study groups.
** P=.029. Student's t-Test, # P<.05 compared to the initial evaluation in the same group.*
One-way ANOVA for repeated measures.

The CKC Pool group showed an initial score of 47.47 ± 17.58, decreasing to 34.13 ± 13.42 points in the partial evaluation (*P*=.04) and to 26.81 ± 14.95 points in the final evaluation (*P*=.00). In the CKC Ground group, the initial score was 38.18 ± 15.47 points, decreasing to 26.18 ± 14.68 points in the final evaluation (*P*=.00) (Table 4).

The CKC Pool group significantly reduced the WOMAC scores in the sub-items pain, stiffness and physical activity, while the CKC Ground group reduced the subscales pain and physical activity (*P*=.00) (Table 4).

The CKC Ground group showed an initial score in the sub-item pain of 8.47 ± 3.55, decreasing to 6.29 ± 3.53 in the partial evaluation (*P*=.03), to 4.88 ± 3.31 in the final evaluation (*P*=.00) and 6.00 ± 3.33 in the follow-up evaluation (*P*=.02). The CKC Pool group showed an initial score in the sub-item pain of the 10.35 ± 4.59, decreasing to 6.44 ± 4.13 only in the final evaluation (*P*=.01). However, in the follow-up evaluation, the score increased to 7.33 ± 4.97 (Table 4).

In sub-item stiffness, only the CKC pool group reduced significantly reduced the score. The CKC Pool group showed an initial score of the 3.18 ± 2.04, decreasing to 1.67 ± 1.97 in the follow-up evaluation (*P*=.05) (Table 4).

In sub-item physical activity, both groups reduced the scores. However, the CKC pool group showed an initial score of 33.94 ± 12.38, decreasing to 23.81 ± 10.04 in the partial evaluation (*P*=.01), to 18.69 ± 10.57 in the final evaluation (*P*=.00). The CKC Ground group showed an initial score of the 27.47 ± 11.90, decreasing to 18.59 ± 10.61 only in the follow-up evaluation (*P*=.00). In the follow-up evaluation, only the CKC Pool group maintained the score significantly lower than the initial evaluation (*P*=.01) (Table 4).

4. DISCUSSION

Due to the lack of studies in the literature comparing the effectiveness of a program of exercises performed in the water and on the ground for patients with knee OA, we sought, through this study, to evaluate the benefits brought with CKC exercises in both therapeutic environments for this population.

Table 4. Values obtained in the WOMAC score domains in the study groups (n = 34)

Variable	Group		
	Ground group (n=17)	**Pool group (n=17)**	***P* value**
WOMAC pain			
Initial	8.47 ± 3.55	10.35 ± 4.59	0.19
Partial	6.29 ± 3.53#	7.75 ± 3.86	0.27
Final	4.88 ± 3.31#	6.44 ± 4.13#	0.24
Follow-up	6.00 ± 3.33#	7.33 ± 4.97	0.53
WOMAC stiffness			
Initial	2.24 ± 2.19	3.18 ± 2.04	0.20
Partial	2.35 ± 2.00	2.56 ± 1.36	0.73
Final	1.71. ± 1.65	1.69 ± 1.49#	0.97
Follow-up	1.4 ± 1.51	1.67 ± 1.97#	0.76
WOMAC physical activity			
Initial	27.47 ± 11.90	33.94 ± 12.38	0.13
Partial	33.06 ± 20.09	23.81 ± 10.04#	0.99
Final	18.59 ± 10.61#	18.69 ± 10.57#	0.98
Follow-up	23.60 ± 12.40	24.67 ± 20.73#	0.90
WOMAC total			
Initial	38.18 ± 15.47	47.47 ± 17.58	0.11
Partial	33.06 ± 20.09	34.13 ± 13.42#	0.86
Final	26.18 ± 14.68#	26.81 ± 14.95#	0.75
Follow-up	31.00 ± 16.75	33.67 ± 27.09#	0.81

 # P<.05 compared to the initial evaluation; ANOVA for repeated measures.

In subjects with knee OA, pain is usually increased by load and relieved by rest [12]. Quadriceps weakness and, often, quadriceps atrophy are common and attributed to muscle disuse, as the patient minimizes painful activities that increase the impact on the knee joint [13]. Moreover, quadriceps weakness may precede and serve as a risk factor for incidental radiographic changes of knee OA [14].

The study sample consisted of thirty-four adult women, with a mean age of 59.29 ± 7.81 years. OA is a common disorder in people over 60 years of age and can significantly affect quality of life [15].

Janssen and Mark [16] observed that abdominal circumference and BMI showed a positive correlation with knee OA. These findings agree with our study, where we observed that the mean BMI of the participants was 30.94 ± 5.92 kg/cm^2, which indicates a direct relationship of the overweight of the participants with the wear generated in the joints. Vasconcelos et al. [17] reported functional limitations of obese subjects in locomotion activities that require weight displacement and discharge on the joints. According to Chacur et al. [18], there is a positive correlation between the functional scores of Lequesne and BMI, suggesting that not only the increase in BMI but also the distribution of fat may aggravate knee OA.

After the 24 treatment sessions, we obtained a significant improvement of pain and function in both groups, which suggests, consequently, an improvement of the quality of life. These findings follow the line of thinking of Fransen et al. [19] and Brandt et al. [20], who reported that kinesiotherapeutic exercises in individuals with knee OA reduce pain and improve functional activity. However, Wyatt et al. [21] reported in their studies that aquatic exercises demonstrate a superior response to pain reduction when compared to ground exercises, immediately following interventions.

Both intervention groups demonstrated a reduction in the values of the Lequesne's Algofunctional Questionnaire, both at the end of the first twelve sessions and at the end of the protocol. The total WOMAC scores improved significantly in both study groups as well. These functional results agree with several studies that also observed a significant decrease in pain pattern, pain and disability, assessed by the Lequesne and WOMAC Questionnaires [21-24].

Knee OA is associated with 50-60% of the reduction in maximum quadriceps torque, possibly resulting from atrophy due to disuse and arthrogenic inhibition [25]. Another study reports that the decrease in quadriceps strength is around 30-50% in individuals with knee OA when compared to healthy individuals within the same age group [26]. Lau et al. [27] reported that OA is directly related to muscle atrophy, decreased strength and reduced ROM, causing difficulty in the DLAs of these individuals. Notwithstanding, muscle strength and ROM in women with knee OA reach 70% of the values of healthy females of the same age and biotype [27]. Sharma et al. [28] reported that laxity and malalignment in valgus and varus may influence the relationship between quadriceps strength and knee OA progression.

According to our study, only the CKC Ground group did not show an increase in left quadriceps strength in any of the evaluations. The CKC Pool group presented results in increasing quadriceps strength and left hamstring strength already with 12 sessions, with an increasing improvement after 24 sessions. In the other evaluations of both groups, an improvement in strength was observed in the final assessment. We observed that, regardless of the place of the therapeutic application, there was an improvement of muscle strength. These results, however, were different from the findings of Lund et al. [29] and Foley et al. [30]. Despite having shown benefits in several other aspects with the performance of aquatic physiotherapy, these authors only found increased muscular strength in the patients subjected to ground therapy. Pool exercises did not show any effect on muscle strength possibly due to little resistance exercise, which is needed to increase muscle strength [29,30]. The reason for the discrepancy of values in the initial evaluations between the groups and the small evolution of quadriceps and left hamstring muscle strength in the CKC Ground group may be related to the predominant injury of the right knee in this group (70,6%).

In the clinical applicability, the results found in this study can guide clinical practices according to the objectives that is wished to achieve with the subject with knee OA. There are significant clinical effects in both environments where CKC exercises are performed. Although previous studies have reported a greater improvement of the muscle strength in the ground, it seems to us that swimming pool exercise in CKC provides a better result in terms of pain relief, improved joint mobility and function of these subjects. However, the availability of the pool environment is not always a reality for the approach of this patient with knee OA. Therefore, exercises performed in ground, if there is control over the intensity, dosage and technique can provide similar results in the rehabilitation process of patients with knee OA.

The study had some limitations such as sample loss. In the follow-up evaluation, due to the loss of contact and the address change of the patients, a sample loss occurred that could interfere with the extrapolation of the results after intervention. The use of viscosupplementation and analgesics/NSAIDs may also interfere with the results.

5. CONCLUSION

The findings of this study allow us to conclude that:

- Both groups improved hamstring flexibility at the end of the study. No loss of flexibility was observed 90 days after the intervention;
- Knee joint flexion mobility improved in both groups, especially after 24 sessions, with no differences between them;
- Both groups demonstrated a decrease in pain after 12 and 24 sessions;
- There was an increase in quadriceps and left hamstring muscle strength in the CKC Pool group, possibly because this group had predominantly the left knee as the most affected and, therefore, with a significantly higher pre-intervention deficit. Both groups increased quadriceps and right hamstring strength with 24 sessions;
- A better functionality of the subjects was observed in both study groups at the end of the intervention;

Our conclusions allow us to affirm that the CKC exercises performed both on the ground and in the pool promoted a decrease in pain and increased mobility, muscular strength and functionality in patients with knee OA. Further studies should be performed to confirm these findings.

CONSENT

As per international standard or university standard, patient's written consent has been collected and preserved by the authors.

ETHICAL APPROVAL

As per international standard or university standard, written approval of Ethics committee has been collected and preserved by the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Bijlsma JW, Berenbaum F, Lafeber FP. Osteoarthritis: an update with relevance for clinical practice. Lancet. 2011;377:2115–26.
2. Jamtvedt G, Dahm KT, Holm I, Flottorp S. Measuring physiotherapy performance in patients with osteoarthritis of the knee: A prospective study. BMC Health Serv Res 2008;8:145.
3. Alnahdi A, Zeni J, Snyder- Mackler L. Muscle impairments in patients with knee osteoarthritis. Sports Health. 2012;4(4): 284-292.
4. Melo S, Oliveira J, Detanico R, Palhano R, Schwinden RM, Andrade MC, et al. Evaluation of muscle strength of knee flexors and extensors in patients with and without osteoarthrosis. Rev Bras Cineantropom Performance Hum. 2008; 10(4):335-340.
5. Farr Ii J, Miller LE, Block JE. Quality of life in patients with knee osteoarthritis: A commentary on nonsurgical and surgical treatments. Open Orthop J. 2013;7:619-23.
6. Gomes WF. Impact of a structured program of aquatic physical therapy in elderly women with osteoarthritis of the knee. [Dissertation]. Belo Horizonte: Federal University of Minas Gerais; 2007.
7. Silva LE, Valim V, Pessanha APC. Hydrotherapy versus conventional land-based exercise for the management of patients with osteoarthritis of the knee: A randomized clinical trial. Phys Ther. 2008; 1(81):12-21.

8. Fransen M, McConnell S. Exercise for osteoarthritis of the knee. Cochrane Database Syst Rev. 2015;(4):CD004376.
9. Fransen M, McConnell S. Land-based exercise for osteoarthritis of the knee: A metaanalysis of randomized controlled trials. J Rheumatol. 2009;36(6):1109-1117.
10. Silva LE, Valim V, Pessanha AP, Oliveira LM, Myamoto S, Jones A, Natour J. Hydrotherapy versus conventional land-based exercise for the management of patients with osteoarthritis of the knee: A randomized clinical trial. Phys Ther. 2008; 88(1):12-21.
11. Hinman RS, Heywood SE, Day AR. Aquatic physical therapy for hip and knee osteoarthritis: Results of a single-blind randomized controlled trial. Phys Ther. 2007;87(1):32-43.
12. Minor MA, Hewett JE, Webel RR, Anderson SK, Kay DR. Efficacy of physical condition in exercise in patients with rheumatoid arthritis and osteoarthritis. Arthritis Rheum. 1989; 32(11):1396-405.
13. Slemenda C, Heilman DK, Brandt KD, Katz BP, Mazzuca SA, Braunstein EM, et al. Reduced quadriceps strength relative to body weight: A risk factor for knee osteoarthritis in women? Arthritis Rheum. 1998;41:1951–9.
14. Slemenda C, Brandt KD, Heilman DK, Mazzuca S, Braunstein EM, Katz BP, et al. Quadriceps weakness and osteoarthritis of the knee. Ann Intern Med. 1997;127:97–104.
15. Simmons V, Hansen PD. Effectiveness of water exercise on postural mobility in the well elderly: an experimental study on balance enhancement. J Gerontol A Biol Sci Med Sci. 1996;51:M233-8.
16. Janssen I, Mark E. Separate and combined influence of body mass index and waist circumference on arthritis and knee osteoarthritis. Int J Obes. 2006;30(8): 1223-8.
17. Vasconcelos KSS, Dias JMD, Dias RC. Relation between intensity and pain and functional capacity in obese individuals with knee osteoarthritis. Braz J Phys Ther. 2006;10(2):213-218.
18. Chacur EP, Silva LO, GCP Light, Silva PL, Baraúna MA, Cheik NC. Obesity and its correlation with osteoarthritis in women. Fisioter Mov. 2008;21(2):93-98.
19. Fransen M, McConnell S, Bell M. Therapeutic exercise for people with osteoarthritis of the hip or knee. A systematic review. J Rheumatol. 2002; 29:1737-45.
20. Brandt KD. The importance of nonpharmacologic approaches in management of osteoarthritis. Am J Med. 1998;105(1B):39S .44S.
21. Wyatt FB, Milam S, Manske RC, Deere R. The effects of aquatic and traditional exercise programs on persons with knee osteoarthritis. J Strength Cond Res. 2001; 15(3):337–340.
22. Aguiar Júnior AS, Gêreminas VC. Effects of hydrotherapy on knee osteoarthrosis. Fisio Magazine. 2003;1(1):12-15.
23. Patrick DL, Ramsey SD, Spencer AC, Kinne S, Belza B, Topolski TD. Economic evatuation of aquatic exercise for persons with osteoarthritis. Medical Care. 2001; 39(5):413-424.
24. Huang MH, Lin YS, Yang RC, Lee CL. A comparison of various therapeutic exercises on the functional status of patients with knee osteoarthritis. Semin Arthritis Rheum. 2003;32:398–406.
25. Hassan BS, Mockett S, Dohert M. Static postural sway proprioception, and maximal voluntary quadriceps contraction in patients with knee osteoarthritis and normal control subjects. Ann Rheum Dis. 2001;60:612-618.
26. Fisher NM, Pendergast DR, Gresham GE, Calkins E. Muscle rehabilitation: its effect on muscular and functional performance of patients with knee osteoarthritis. Arch Phys Med Rehabil. 1991;72(6):367-374.
27. Lau MCK, Lam JKS, Siu E, Fung CSW, Li KTY, Lam MWF. Physiotherapist designed aquatic exercise programme for community dwelling elders with osteoarthritis of the knee: A Hong Kong pilot study. Hong Kong Med J. 2014; 20:16–23.
28. Sharma L, Dunlop DD, Cahue S, Song J, Hayes KW. Quadriceps strength and osteoarthritis progression in maligned and lax knees. Ann Intern Med. 2003; 138:613–619.
29. Lund H, Ulla Weile U, Christensen R, Rostock B, Downey A, Bartels EM, Danneskiold-Samsøe B, Bliddal H. Randomized controlled trial of aquatic and land-based exercise in patients with knee osteoarthritis. J Rehabil Med. 2008;40: 137–144.

30. Foley A, Halbert J, Hewitt T, Crotty M. Does hydrotherapy improve strength and physical function in patients with osteoarthritis – a randomized controlled trial comparing a gym based and a hydrotherapy based strengthening programme. Annals of the Rheumatic Diseases. 2003;62:1162-1167.

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